Oxygen-enhanced MRI of the lung: Optimized calculation of difference images

O. Dietrich1, M. Peller1, U. Fasol1, C. Losert1,2, K. Nikolaou1, M. F. Reiser1, S. O. Schoenberg1

1Department of Clinical Radiology - Grosshadern, Ludwig Maximilian University of Munich, Munich, Germany, 2Department of Radiotherapy and Radiation Oncology, Ludwig Maximilian University of Munich, Munich, Germany

Introduction: Oxygen-enhanced MRI (O2-MRI) of the lung allows spatially resolved visualization of oxygen diffusion from the alveoli into the capillaries of the lung [1–5]. A commonly used method to assess lung function by O2-MRI is to calculate the relative signal difference of acquisitions during inhalation of pure oxygen and room air [1–4]. After switching the gas supply, a relatively slow signal change with time constants between 30 s and 70 s is observed (cf. Fig. 1) [5]. Since these time constants can also be used to assess the lung function [4], a continuous data acquisition is desirable. The purpose of this study was to analyze how difference maps of continuously acquired data are influenced by this slow signal change.

Subjects and Methods: 10 healthy volunteers were examined with an ECG- and respiratory-triggered T1-weighting inversion recovery HASTE sequence (TI = 1300 ms, TE = 11 ms, TR: 1 respiratory cycle, slice thickness 8 mm, slice distance 16 mm) implemented on a 1.5 T whole-body scanner (Magnetom Sonata, Siemens Medical Solutions, Germany). Parallel imaging (acceleration factor: 2) with the GRAPPA algorithm was used to reduce the TE and to increase the maximum number of slices acquired per respiratory cycle. 4 blocks with 20 repetitions of 4 or 6 coronal slices were continuously acquired; in blocks 1 and 3 room air was supplied, in blocks 2 and 4 oxygen. Data was post-processed discarding between \( n=0 \) and \( n=19 \) repetitions after each change of gas supply before calculating the relative signal difference \( \Delta S_{rel} = (S_{O2} - S_{air}) / S_{air} \); see Fig. 1. To assess the data quality of the resulting difference map, the (“spatial”) standard deviation of the pixel-wise calculated signal difference within the lung tissue was determined.

Results: As shown in Fig. 2a, the averaged relative signal difference is increasing from 9.4 % to 17.4 % and the spatial standard deviation of the signal difference is increasing from 6 % to 14 % when the number of discarded acquisitions is increased. The ratio of signal difference and spatial standard deviation has a maximum at 5 to 8 discarded acquisitions (Fig. 2b). Examples of difference maps demonstrating increasing statistical noise with increasing number of discarded measurements are shown in Fig. 3.

Conclusions: An optimized ratio of signal difference and statistical error is found if about 5 to 8 of 20 repetitions (corresponding to 5 to 8 respiratory cycles, i.e. about 60 seconds) are discarded after each change of gas supply for the calculation of difference maps.

Acknowledgments: This study was supported by the Deutsche Forschungsgemeinschaft (DFG), PE 925/1-3.

References: